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FACULTY OF BIOSCIENCE ENGINEERING

Bio-based fertilizers for greenhouse cropping: a lab and field scale assessment

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INTRODUCTION

Taking into consideration high fertilizer demand, the rapid nutrient depletion, the significant amount of fossil energy and subsequent cost required for the production of mineral fertilizers, it has become an important challenge to maximally recycle valuable nutrients that are currently found in waste streams.

This study evaluates the impact of using waste stream derivatives (*liquid fraction of digestate, struvite, ammonium sulphate and effluent from constructed wetlands)* on soil quality and crop *(Lactuca sativa L.)* production as bio-based mineral fertilizer substitutes.

MATERIALS AND METHODS

1. LAB SCALE ASSESSMENT

- *Lactuca sativa L.* = salt sensitive crop with the soil maximum electrical conductivity (EC) tolerance of 1.8 dS m^{-1}
- An explorative pot- experiment required to evaluate the impact of bio-based mineral fertilizer substitutes (Figure 1) with respect to soil EC
- 16 pots (blank=1, n=3) filled with bio-based products (acc. crop requirements) and soil collected from the greenhouse foreseen for the field scale assessment
- Results indicated soil EC values within the stipulated limit of 1.8 dS m^{-1}

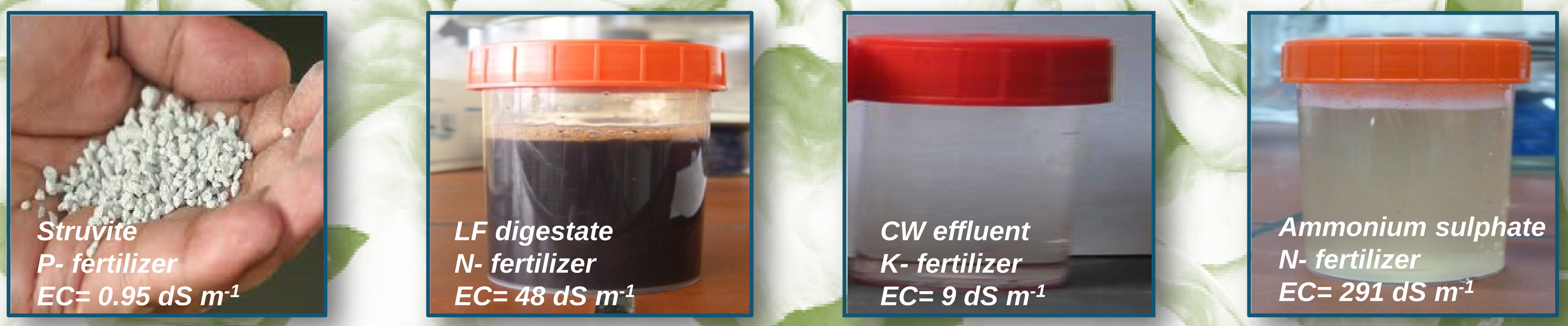

Figure 1. Bio-based mineral fertilizer substitutes

2. FIELD SCALE ASSESSMENT

- Location: Kruishoutem, Belgium
- Total greenhouse area: 752 m^2 (376 m^2 per greenhouse)
- Complete randomized block trial (block = 10 m^2)

Table 1. Product dosage applied for the eight different fertilization treatments (Sc. 1a and 1b with mineral fertilization = reference, n = 4) per block (10 m²)

Individual substitution (Greenhouse 1)							
Scenario	CAN (kg)	TSP (kg)	PAT (kg)	STR (kg)	AMS (L)	CW (L)	LFD (L)
1a	0.78	0.27	0.80	-	-	-	-
2	0.65	-	0.78	0.59	-	-	-
3	-	0.27	0.80	-	2.5	-	-
4	0.78	0.27	-	-	-	161	-
5	-	0.21	0.25	-	-	-	40

Combination substitution (Greenhouse 2)							
Scenario	CAN (kg)	TSP (kg)	PAT (kg)	STR (kg)	AMS (L)	CW (L)	LFD (L)
1b	0.78	0.27	0.80	-	-	-	-
6	-	-	-	0.59	2.0	157	-
7	-	-	0.27	0.45	-	-	35
8	-	-	0.75	0.59	2.0	-	-

CAN = calcium ammonium nitrate, TSP = triple superphosphate, PAT = patentkali, STR=struvite, LFD = liquid fraction of digestate, CW = effluent from constructed wetlands, AMS = ammonium sulfate

3. FERTILIZATION AND TRANSPLANTING

- Total N system
- NPK crop requirements: 210-125-240 kg/ha

Figure 2. Fertilization (13/06/2013) and transplanting (14/06/2013)

4. PHYSICOCHEMICAL ANALYSIS

Physicochemical analysis:

- Soil: DM, OM, total and plant available macro- nutrients, Cu, Zn, pH and EC
- Crop: Fresh weight, DM, OM, total macro-nutrients, Cu and Zn

Crop quality assessment *(determined by observation and evaluated on a scale basis):*

- Bremia (*Bremia lactucae),* tipburn, yellow leaves, basal rot, uniformity and volume

RESULTS

- In both greenhouses, substitution did not lead to significant reduction or increase in crop yield (Figure 3) with respect to mineral fertilization (reference 1a and 1b)

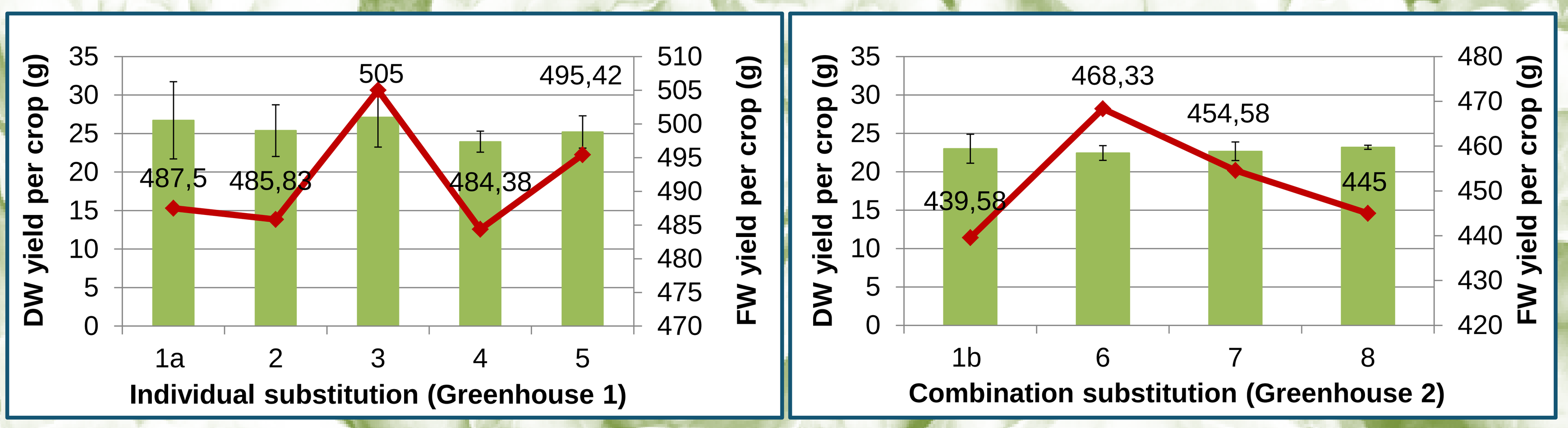

Figure 3. Fresh weight and dry matter yield per crop (n=12)

- In both greenhouses, substitution did not lead to reduction or increase in plant nutrient uptake (Figure 4) in compare to mineral fertilization (reference 1a and 1b)

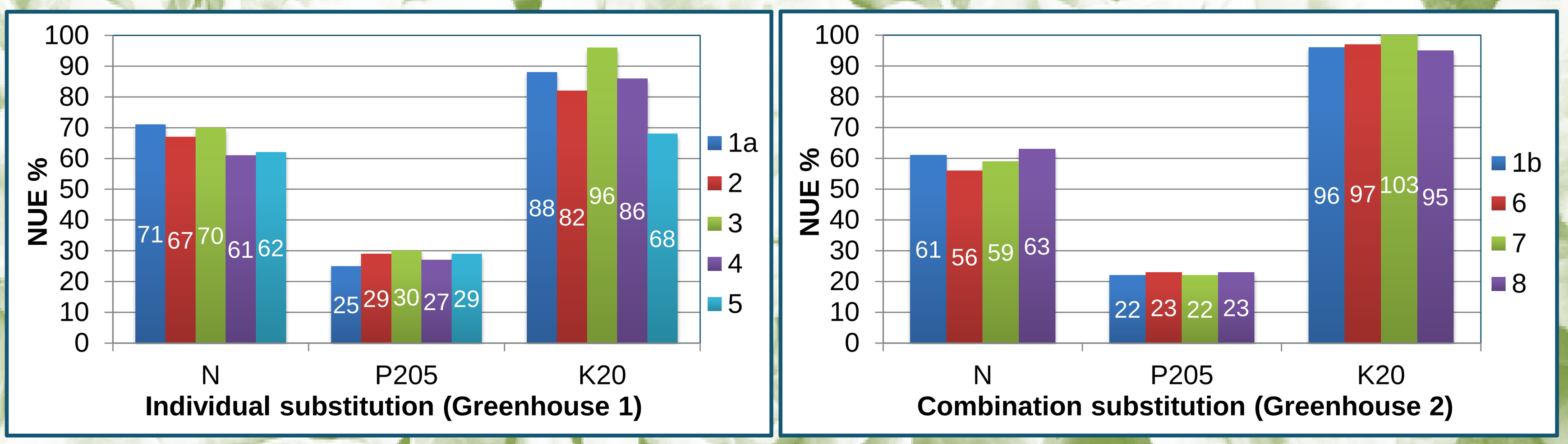

Figure 4. Fertilizer Nutrient Use Efficiency (NUE) per treatment (=percentage of nutrients taken up by crop in comparison to nutrients applied via fertilizer application)

- During the entire growing period and at harvest time, Sc. 5 and 7 with LF of digestate as a N- fertilizer, resulted in lower crop volume and uniformity (Table 2)
- For the other crop quality parameters, no significant differences were observed among eight different fertilization treatments

Table 2. Score given on the basis of visual observation for the crop volume and uniformity during the growing period (21/06/2013 and 04/07/2013) and at harvest (17/07/2013) as a part of the crop quality assessment

Treatment	21/06/2013		04/07/2013		17/07/2013	
	Volume	Uniformity	Volume	Uniformity	Volume	Uniformity
1a	6.50	7.25	6.75	6.25	8.00	8.00
2	6.75	7.00	7.25	6.25	7.75	7.50
3	7.25	7.25	7.50	6.75	7.75	7.50
4	7.75	7.00	6.25	5.25	7.00	7.00
5	6.00	6.25	6.25	5.00	7.00	6.75
1b	6.75	7.00	7.25	6.50	8.00	7.00
6	8.00	7.00	7.50	6.75	7.00	7.50
7	5.75	6.25	6.00	4.50	7.50	6.25
8	7.25	7.25	7.25	7.00	8.00	7.75
1=	Small volume	Heterogeneous	Small volume	Heterogeneous	Small volume	Heterogeneous
9=	Voluminous	Homogeneous	Voluminous	Homogeneous	Voluminous	Homogeneous

- Individual substitution: no significant difference observed in soil nitrate residue at harvest time due to high standard deviations (Figure 5) that were obtained in treatments with CW effluent (Sc.4) and LF digestate (Sc. 5)
- Combination substitution: significant decrease of nitrate residue in Sc. 6 (Figure 5) as a consequence of leaching that was caused by applying 157 L of CW effluent and 2 L of ammonium sulfate on the surface area of 10 m² (Table 1)

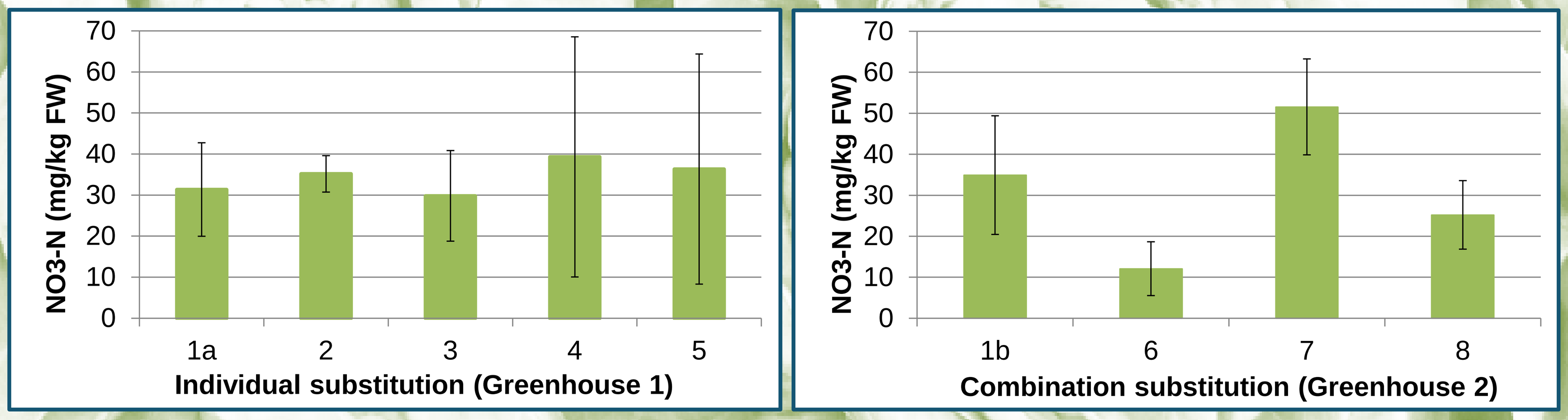

Figure 5. Nitrate residue in soil at harvest time (17/07/2013), n=4

CONCLUSION

- Out of four tested products, ammonium sulphate and struvite gave the best result
- CW effluent should be more concentrate, since in its current form leaching may occur
- For LF of digestate further research is needed in order to identify its impact on plant growth